Astrophysics

Thermally and Cosmic Ray Driven Galactic Winds for Observational Diagnostics and Galaxy Formation Simulations

Completed Technology Project (2016 - 2017)

Project Introduction

Galactic winds are believed to play a significant role in galaxy formation feedback; however, the physical processes that determine the structure of galactic winds are often on too small scales to be properly accounted for in cosmological codes. The unresolved structure and/or incomplete parameterization of galactic winds may be one reason why many models overestimate the number of low-mass galaxies in the universe. I propose to continue development on a class of galactic wind models that will be tested against observations and ultimately implemented in cosmological simulations of galaxy formation in order to reproduce the observed abundance of low-mass galaxies in our universe. My past work (Bustard et al. 2016) improved upon the widely-used Chevalier and Clegg (1985) model of galactic winds and illuminated which combinations of mass-loading and energy-loading from supernovae would be most efficient in expelling mass from a galaxy, provided a physical reasoning for the abundance of low-temperature, high-velocity outflows seen in observations, and successfully reproduced the observed linear relationship between star formation rate and galaxy X-ray luminosity (Mineo et al. 2012). The main focus of my future work will be the inclusion of a magnetic field and a second, cosmic ray fluid to my thermally driven wind model. Previous simulations have shown cosmic rays to be extremely efficient in driving a wind. This work will constitute an exploration of a number of different models of cosmic ray interactions and driving mechanisms, and it will provide observable tests of cosmic ray driven winds. Further improvements on my model will also include photoionization heating from the surrounding background radiation of the galaxy, which may keep winds from radiatively cooling to catastrophically low temperatures. I will also model the interaction between a wind and the surrounding intergalactic medium. Diffusive shock acceleration from shocks produced when the wind propagates into this medium are a proposed mechanism for high-energy cosmic ray production, and the temperature increase of the post-shock gas may also have interesting implications when compared to observations. Overall, this work will provide observational diagnostics spanning a large range of wavelengths from optical to gamma-ray, which will then be compared to observations from JWST, HST, and other instruments. These observations will constrain the parameters of my model, providing a physically motivated, observationally consistent model of galactic outflows that I will then include in a galaxy formation simulation to analyze an outflow's effect on galaxy feedback.

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Table of Contents

Organizational Responsibility

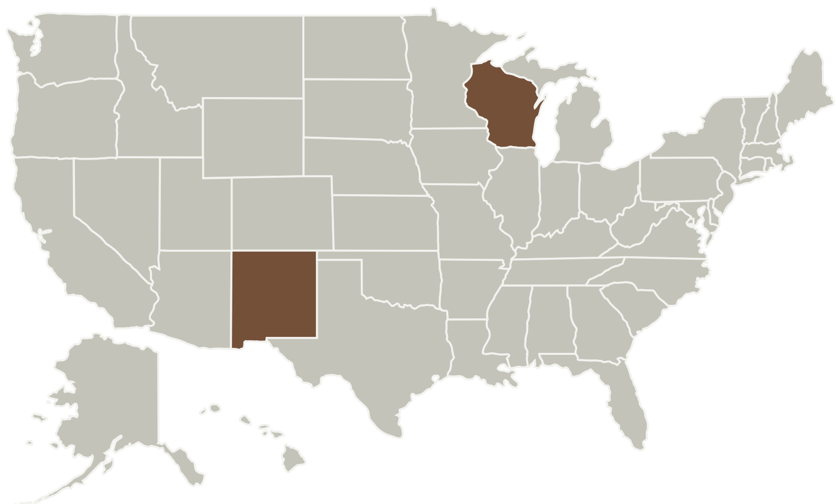
Responsible Mission Directorate:

Science Mission Directorate (SMD)

Responsible Program:

Astrophysics

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of Wisconsin-Madison	Supporting Organization	Academia	Madison, Wisconsin

Primary U.S. Work Locations	
New Mexico	Wisconsin

Project Management

Program Manager:

Joe Hill-kittle

Principal Investigator:

Ellen Zweibel

Co-Investigators:

Darlene Holte
Chad Bustard

Technology Areas

Primary:

- TX09 Entry, Descent, and Landing
  └ TX09.4 Vehicle Systems
    └ TX09.4.5 Modeling and Simulation for EDL

Target Destination

Outside the Solar System